—FINAL TECHNICAL REPORT—

00HQ-GR-0016

CONTINUOUS BROADBAND MONITORING OF STRAIN CHANGES NEAR THE SAN ANDREAS FAULT

February 1, 2000 — January 31, 2002

Submission date: September 5, 2003

Program Elements: II

Duncan Carr Agnew and Frank K. Wyatt

Institute of Geophysics and Planetary Physics
University of California, San Diego
La Jolla, California 92093-0225
(858) 534-2411, fax (858) 534 5332, fwyatt@ucsd.edu

00HQ-GR-0016

CONTINUOUS BROADBAND MONITORING OF STRAIN CHANGES NEAR THE SAN ANDREAS FAULT

February 1, 2000 — January 31, 2002

Submission date: September 5, 2003

Program Elements: II

Duncan Carr Agnew and Frank K. Wyatt

Institute of Geophysics and Planetary Physics
University of California, San Diego
La Jolla, California 92093-0225
(858) 534-2411, fax (858) 534 5332, fwyatt@ucsd.edu

Abstract

This grant supported the operation of a 524-m-long laser strainmeter adjacent to the southern San Andreas Fault, funded by the US Geological Survey at this site since 1994. This device measures the change in distance between its ends to within a fraction of a wavelength of light. These measurements allow us (1) to measure the properties of the rocks in and around the fault zone, (2) to understand how ground deformation in this active area compares with that elsewhere in California, and (3) to detect small motions on the fault should they occur. These measurements provide information on behavior of the San Andreas Fault at its southern end: one end of that segment of the San Andreas which has the longest elapsed time since the last large earthquake. In the event of a large earthquake on this segment, this instrument would provide an unexcelled baseline measurement of precursory deformation.

Observations show the strainmeter to be faithfully recording the elastic build-up of fault strain; other than this, over the period covered by this grant we have not seen unusual strain changes, including at the time of an unusual earthquake swarm (in late 2001) on the Brawley Seismic Zone nearby.

CONTINUOUS BROADBAND MONITORING OF STRAIN CHANGES NEAR THE SAN ANDREAS FAULT

00HQ-GR-0016

Duncan Carr Agnew and Frank K. Wyatt

1. Introduction

This grant provided funds to operate a long-base laser strainmeter at a site (DHL) close to the southernmost section of the San Andreas Fault (**Figure 1**) and to analyze and model the data produced by this instrument and by other measurements in the area. This data collection and analysis provides important information about strain in seismic zones, especially near the termination of the Indio segment of the San Andreas Fault, identified as a likely initiation point for a future major earthquake on this segment of the San Andreas.

What do we get from the higher sensitivity of strainmeters that could not be measured with continuous GPS or other techniques? Our list includes:

1. Strain rates within a fault zone. Most geodetic data span the fault with an aperture of 10-30 km, leaving the details of the strain within this zone uncertain. If part of the observed motion on these scales is distributed in inelastic deformation close to the fault, the rate of elastic deformation, and the seismic hazard, would be lower. Secular strain measurements within the zone of possible inelastic deformation can establish if this is occuring.

2. Interseismic slip behavior. A continuous strain-measurement system allows us to detect (or at least to put limits on) the nature of fault motion over a wide range of frequencies, from minutes to years. This is not the same as looking for precursors (#4 below): rather, we aim to study aseismic fault slip, associated with large earthquakes or not, something much better done with strainmeters than geodetic measurements. Specifically, we want to ask if fault slip at depth is steady or not at periods of less than one year. Our results from PFO have not shown convincing departures from steady strain accumulation, except postseismically (dramatically so for the Landers earthquake). We wish to extend this to other settings. If measurements in an active fault zone reveal the same level of strain fluctuation as we have seen at PFO, it would imply that the PFO data are more probably representative of the rest of California, with profound consequences for what kind of overall strain monitoring should be undertaken.

3. Fault-zone rheology. A long-base strain measurement will give a good record of the earth tides and can provide us with a collection of teleseismic recordings, unaffected by the localized distortions present in borehole strain and tilt data. If fault zones are "soft" compared to the surrounding rock, thereby concentrating strain, this should be obvious in tidal and seismic data from such instruments.

4. Precursory anomalies. The most "applied" reason for making high-quality strain measurements along the southern San Andreas (or indeed in any other fault zone) is also the one with the least chance of happening: to detect deformation premonitory to an impending great earthquake.

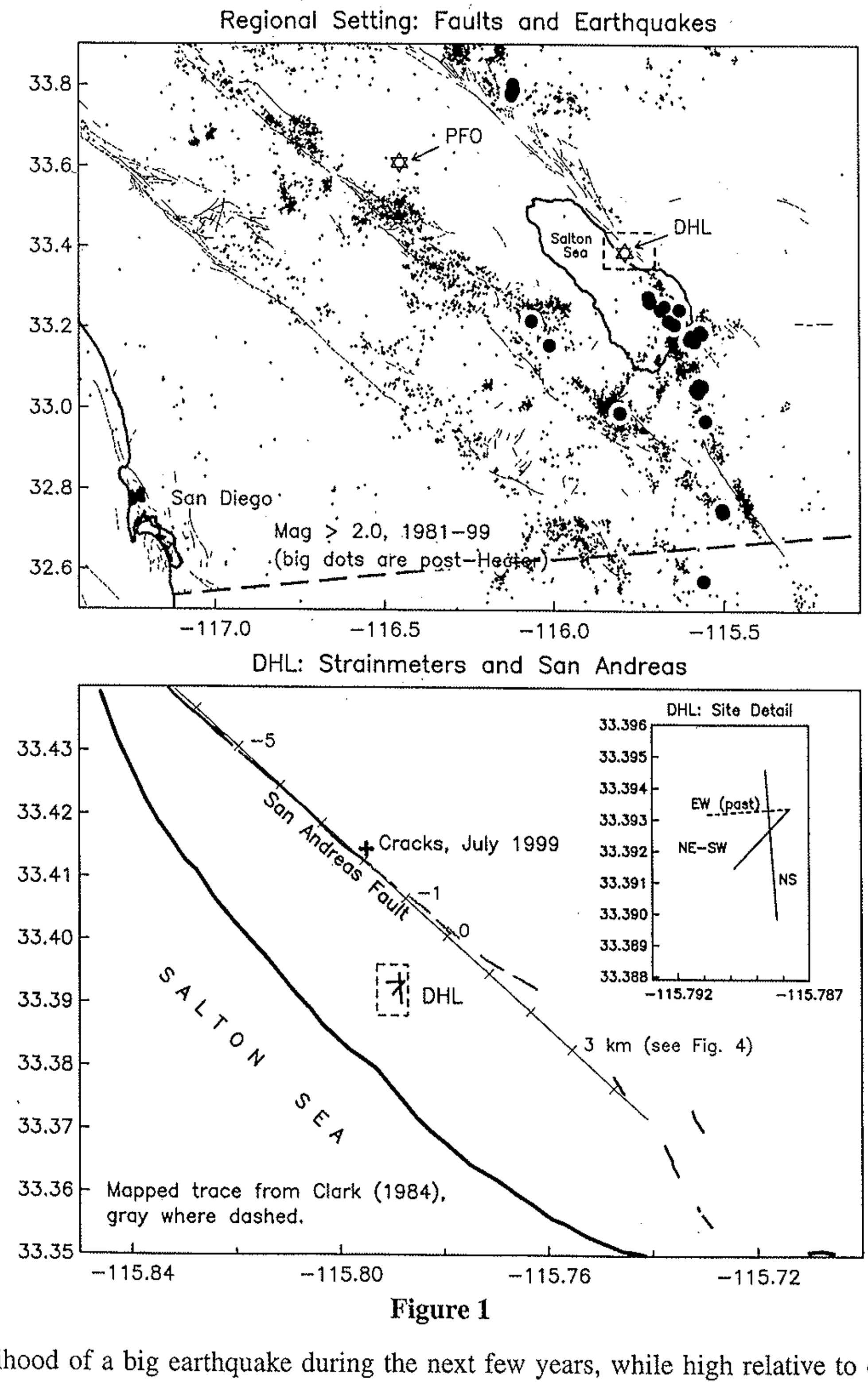

Figure 1

The likelihood of a big earthquake during the next few years, while high relative to other locations, is still so low that the odds are heavily against this occurring in any given year. We thus must plan our measurements around the results described above, rather than staking all on such an unlikely chance. One aspect that improves our chances of learning something about precursory signals (and applies equally to aims (#2) and (#3)) are the concurrent observations from PFO—the search for such signals is strengthened greatly by having instruments at two locations.

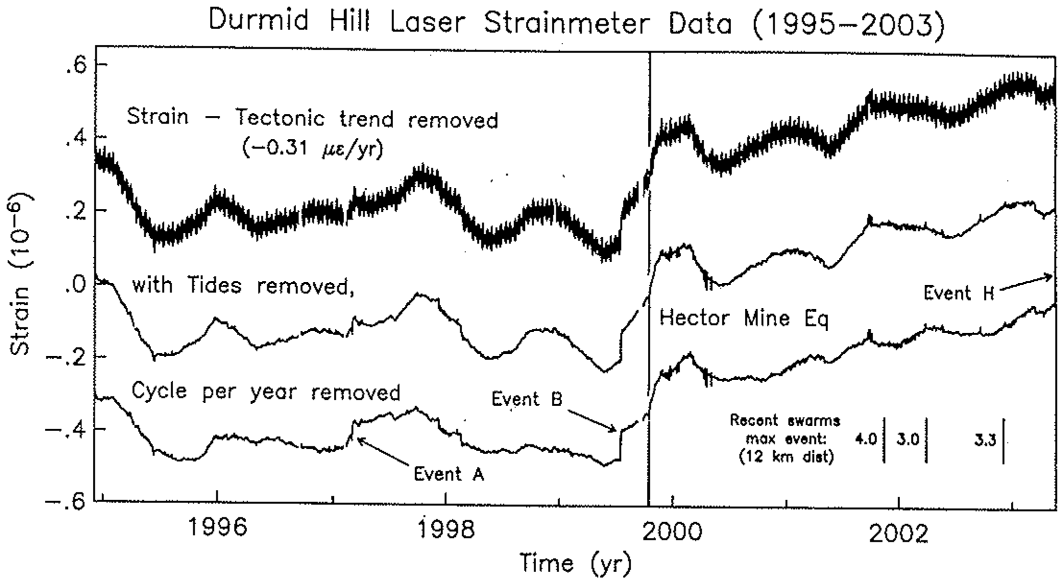

Figure 2

2. Recent Events

The award provides funding solely for operation of the strainmeter at DHL. The most important result for this period, which is included in the longer span of data shown in **Figure 2**, is that the pattern of strain accumulation has not returned to what we have observed during most of the period of operation (since 1995): the long-term rate, after a perturbation in the summer of 1999, and especially following the M 7.1 Hector Mine earthquake (1999:289:09) and the very nearby M 5.1 and 4.6 triggered events (and subsequent aftershocks), has remained different from its previous secular rate. We have also recently seen some additional "strain events" [Event H] of the type we saw during the last half of 1999, which we believe are related to local fault slip. The strainmeter generally continued to operate well with the period being largely free of operational problems.

The most unusual event during this period was on day 317 of 2001, when there was an earthquake swarm just 5 km SSE of Bombay Beach, at the end of the San Andreas, giving rise to community concern over accelerated deformations. We checked the data and discussed it with interested parties, including Ken Hudnut, and Will Prescott of the USGS, and Michael Reichle (CGS), for input to a CEPEC dicussion to advise the Office of Emergency Services. The lack of any accelerating signals on the strainmeters was taken into account in this discussion.

We continued to have a real-time high-speed telemetry link, courtesy of the Anza Seismic Network, which now provides data at 100 samples-per-second for the strainmeter at the site. (The "portable strainmeter" operated with NSF funding at this site was turned off on 31 Januray 2002.)

To better understand the response of the instrument, in October 2001 we devoted extra effort to monitoring the passage of large freight trains past the facilty, including getting train weights from the railroad. The results make more precise, but no more clear, the earlier results shown in **Figure 3**: the response has the wrong sign, indicating that a local load causes motion away from the load, rather than towards it as expected for a halfspace. We are investigating theoretical reasons for this.

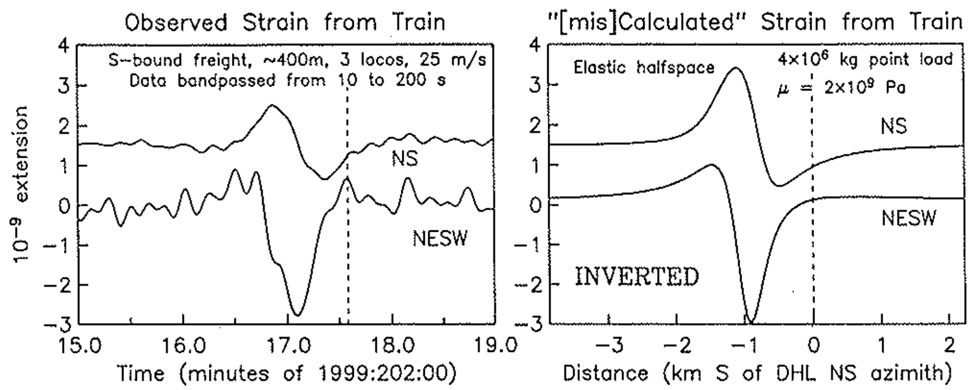

Figure 3